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Researching ‘messy objects’: How can boundary objects strengthen the analytical pursuit of an Actor-Network Theory study?

This paper offers a detailed consideration of how the theoretical scope of the boundary object concept fits within an actor-network theory (ANT) sensibility when researching ‘messy objects’. Messy objects are artefacts whose relational effects are inherently slippery and complex. As the aim of ANT is to show how non-human and human actors are co-constitutive in performing social activity, the uptake of boundary objects in ANT studies may appear to be an expedient analytical endeavour. However, scholars have raised concerns that the boundary object concept has lost some of its original analytical bearing, and that it is theoretically incompatible with ANT. This paper argues that a more careful reading of boundary objects’ conceptual origins can provide useful insights for an ANT study. To illustrate this argument, findings are presented from an ethnographic study of engineers’ knowledge practices in an emerging industry. Specifically, it shows that when a messy object – a signature on a contract – is foregrounded as a boundary object, particular knowledge practices are made visible. However, due to the complexity and messiness of the signature’s performance, this paper contends that a pluralist theoretical approach to analysing messy objects may be more helpful to address issues of professional practice and knowledge.

Keywords: actor-network theory, boundary objects, sociomaterial, messy objects, signature

Introduction

Studying the role of objects in professional practice is becoming an increasingly valuable focus for researchers studying complex organisational work, and issues of knowing and learning (Carlile 2002; Nicolini, Mengis, and Swan 2012; Orlikowski and Scott 2008). Depending on the way in which an object is being used in practice, various theoretical approaches have been proposed to analyse its effects, for example, it could perform as an affiliative object (Suchman 2005), epistemic object (Knorr Cetina 1997),

intermediary object (Boujot and Blanco 2003), or boundary object (Star and Griesemer 1989). In this paper, I explore how the latter approach can strengthen the analytical pursuit of an actor-network theory (Latour 1987) study when exploring the effects of 'messy objects' in mediating collaborative work. 'Messy objects' are objects that necessarily evade thorough exploration by researchers, due to their inherent complexity (Law and Singleton 2005).

First introduced nearly 30 years ago, Star and Griesemer's (1989) notion of boundary object has become a powerful concept to explain how non-human artefacts can generate interpretative flexibility that afford coordination of activities across diverse social spheres. These artefacts may be abstract, such as '…techniques, and ideas, stories and memories' (Bowker and Star 2000, 298) as well as concrete (e.g., maps, sketches and texts). Fundamentally, boundary objects are things that generate action towards and with other entities (Star 2010).

The explanatory power of boundary objects to elicit mediation in collaborative workplace practices has been well documented in organisation and management literature, for example, in cross-collaboration (Nicolini, Mengis, and Swan 2012), coordination (Bechky 2003; Carlile 2002), project contract negotiation (Koskinen and Makinen 2009) scheduling (Yakura 2002), and partnering (Bresnen 2010; Windeck, Weber, and Strauss 2015), as well as in computer supported cooperative work (e.g., Henderson 1999; Lee 2007). The concept has also flourished in education scholarship (Akkerman and Bakker 2011), most explicitly in activity theory (Engeström 1987) and communities of practice (Wenger 1998). However, in this paper, I am interested in how the concept fits with actor-network theory (ANT) (Callon 1986; Latour 1987; and Law 1992), specifically when studying 'messy objects'.

Similar to that of the concept of boundary objects, ANT's aim is to decentre the human in social research. By describing the social and material relational practices, or the networks, which underlie the practice in question, ANT is often termed a sociomaterial approach (Fenwick and Edwards 2010). While several studies have explicitly coupled the boundary object concept with an ANT study (e.g. Bresnan 2010; Briers and Chua 2001; Sage, Dainty, and Brookes 2010), various scholars have expressed concerns regarding the appropriateness of using the boundary object concept to analyse knowledge work in an ANT study. This paper focuses on two of these concerns in particular.

Firstly, Lee (2007), Zeiss and Groenewegan (2009) and Nicolini, Mengis, and Swan (2012) highlight that the concept's popularised adoption in research may be resulting in a 'catch-all' approach (Lee 2007, 310) for analysing '*all* the types of work performed by material and symbolic entities' (Nicolini, Mengis, and Swan 2012, 614). Star (2010) worries that this has caused the concept to become unanchored from its original analytical intention.

Secondly, the concept's fit, apropos to an ANT sensibility, has been contested due to incompatible theoretical origins. Although Star and Greisemer (1989) drew heavily on the work of ANT scholars, Trompette and Vinck (2009) point out that the original boundary object concept derives from a symbolic interactionist tradition, and is focused on an ecological perspective of collective action and innovation. It is concerned with theorising how those from several social worlds align cognitively to make sense of a given situation (an epistemological approach), rather than describing the networks of relations (raising ontological questions), which would be the concern of an ANT study. When bringing together concepts from different theoretical underpinnings, there is the danger that studies simply tend to either ignore such tensions, or do not provide deeper

reflections on the analytical implications of combining these approaches (Modell, Vinnari, and Lukka 2017).

The aim of this paper is to address these two concerns by exploring the theoretical underpinnings of boundary objects in more depth, looking for points of affinity and points of difference with ANT. To pursue this line of enquiry, I draw on an analysis of empirical data gathered during an ethnographic study, which explored how engineers' professional knowledge was enacted, in practice, in an organisation based in the wind energy industry (Scoles 2018). In particular, this study sought to further theorise how to analyse the multiple performances of complex, non-human objects, and their role in generating knowledge practices (Orlikoswi and Scott 2008).

Following a relational approach, ANT considers 'objects' as being performed into reality through complex gatherings of social and material relations (for example, a textbook can be seen as a gathering of text fonts, curricula, publishers, editors, deadlines, laptops, and so on). In emerging industries, and other knowledge-intensive industries, the relations that are assembled to perform an object can be so inherently complex and distributed that researchers are unable to capture all of the various threads of the object at once. These may be called 'messy objects' (Law and Singleton 2005). This paper focuses on how one such 'messy object' – a signature on a sales contract – circulated to produce particular knowledge practices. By foregrounding this messy object, the signature, as acting as a boundary object, this paper explores how the boundary object concept could strengthen the analytical pursuit of an ANT-inspired study. This exploration is based on three research questions, which are informed by the two concerns indicated above:

(1) Does the ANT study in question respect the original purpose of the boundary object concept?

(2) How does the boundary object approach fit, theoretically, with ANT?

(3) In this ANT analysis, does the boundary object concept sufficiently account for the complexity and messiness of collaborative work unfolding in an emerging industry?

This paper unfolds as follows. Firstly, I offer an overview of the theoretical approaches in question: boundary objects and actor-network theory. I then describe several concerns that have been raised about working with these concepts concomitantly. I move to summarise the empirical case, which I use to illustrate how the boundary object concept can be appropriated in an ANT analysis when researching a messy object. I outline the methodological approach and analytical strategies I adopted to trace the work of a messy object: the signature. Two posthuman anecdotes are then presented, which make visible particular knowledge practices emerging in engineers' collaborative work. Finally, I discuss how these anecdotal findings help address the three questions posed above.

Concepts and concerns: situating boundary objects and actor-network theory

Boundary Objects

In their study of a natural history museum, Star and Griesemer (1989) developed the concept of boundary objects to show how diverse actors who shared the same objectives (promoting the protection of flora and fauna species) succeeded in co-operating over 30 years, despite competing and divergent perspectives. Objects, such as field notes, specimens and maps, became focal points, which enabled actors to maintain a plurality of perspectives while still achieving progress towards their individual objectives and without necessarily reaching consensus.

One of the central characteristics of boundary objects are their 'interpretative flexibility'; they can act as 'both plastic enough to adapt to local needs and the constraints of several parties employing them, yet robust enough to maintain a common identity across sites' (Star and Griesemer 1989, 393). For example, Yakura (2002) studied timelines as temporal boundary objects to illustrate that 'time' could be rendered momentarily visible and concrete, which allowed actors from various groups to negotiate and manage their activities. Koskinen and Makinen (2009, 34) looked at the role of boundary objects in negotiations of project contracts, and showed how the contract embodied 'the negotiators' interpretation of the "world" made into a collective reality', which had folded in to it multiple view points and demands.

The concept has also been helpful in illuminating issues of power (e.g., Bechky 2003; Sage, Dainty, and Brookes 2010). For example, in Bechky's (2003) study of engineers, she showed how two objects, engineering drawings, and machines, not only mediated problem-solving between three different occupational groups in a manufacturing firm, they also served to strengthen issues of power amongst different occupations, through what she terms 'occupational jurisdiction': '[f]or drawings to be powerful as a tool to maintain occupational jurisdiction, they must be somewhat unclear to other groups, because if every aspect of their work was easily codified and understood, engineers would be unable to maintain their status as experts' (735).

However, Trompette and Vinck (2009, l) have revisited the notion of the boundary object, highlighting how it has lost its 'original analytical momentum', due to an over-emphasis on the concept's 'interpretive flexibility' characteristic (Star 2010). A naive approach to this characteristic raises the question; can't anything be treated as a boundary object? Star (2010) uses the American flag, and the Bible, as examples of objects for which many people have different interpretations. But this anecdotal

approach to the boundary object concept leaves any analytical explanation wanting. Star (2010, 613), says it is more helpful to work with the idea of a boundary object by selecting a specific scope, for example, to 'study people making, advertising, and distributing American flags, and their work arrangements and heterogeneity' and within a specific scale, for example, at the organisational level.

By foregrounding the interpretative flexibility characteristic, other aspects of boundary objects are often over-looked, which include 'the material/organizational structure of different types of boundary objects' (Star 2010, 602) and methods of standardisation (Lee 2007). Bowker and Star (2000) extended the original work to consider how multiple boundary objects and systems of boundary objects could develop into 'boundary infrastructures'. Star (2010, 602) contends that these spontaneous infrastructures arise when 'information and work requirements' act as conduits for local groups to work cooperatively, often resulting in a 'standardized form'. Lee (2007) and Trompette and Vinck (2010) note that a focus on the enactment of these invisible infrastructures is often missing from boundary object studies.

As with all concepts, the boundary object is not without its conceptual limitations. Thompson, Macpherson, and Herbane (2017) highlight two common critiques. First, boundary objects are often stable entities that are 'uncovered' in predictable rather than turbulent or, in the case of this paper, emergent, environments. Second, they tend to be discussed in terms of simple relationships, and their analytical ability in more complex and dynamic collaboration has generally been overlooked. Highlighting these limitations leads the paper on to explore the second theoretical concept in question – Actor-Network Theory – and how it fits, theoretically, with the boundary object concept.

Actor Network Theory

Originating in science and technology studies in the 1980s, ANT (Callon 1986; Latour 1987; Law 1992) offers a relational understanding of the social. Reality is not something 'out there' to be captured by the scientist, but is repeatedly performed into existence. This perspective foregrounds the importance of things, artefacts, or objects (as they are called in various writings), in analysing social life. The essential foundation of ANT is that it considers both humans and non-humans capable of bestowing agency and exerting force, in 'symmetry' (Latour 1987).

Similar to boundary objects studies, ANT inquiries are largely empirical and ethnographic in design (e.g., Callon 1986). Latour (2005, 12) encourages the ANT researcher to eschew categorical representations and dichotomies, such as subject/object and individual/community, and to flatten the social by tracing the entities that come together to perform particular knowledges, or 'facts', into existence. His methodological advice is 'to follow the actors' in a slow and detailed approach. These actors are both human and non-human, and the researcher's focus is on the relationship – the associations – that are created as these actors connect to form a network. The term 'translation' describes how these actors connect (or fail to connect) to form a web of activity, and how they are thus changed, or translated, in becoming part of this network.

Latour (2005, 71) defines an actor as 'any thing that does modify a state of affairs by making a difference', and employs the terms 'intermediary' and 'mediator' to indicate how the role of actors can be both passive and active. An intermediary is an entity that, 'transports another force or meaning, without acting on it to change it' whereas a mediator, 'can transform, distort or modify the meaning in the elements it is to conduct' (Fenwick and Edwards 2010, 1). The roles of the actors are not fixed: a mediator can become an intermediary, and vice versa. Thus, actors not only reshape other actors, but can be remade themselves. Following this logic, a boundary object may

be considered both passive and active, depending on its role in the network at a particular time.

Inherent to this networked understanding are power relations, or, as Latour (1986, 273) might say, 'the vague notion of power'. This notion is helpful to conceptualise how networks of power are disturbed through different ways of ordering, where no actor inherently holds more power, knowledge or complexity than the other; it is only through the different connections between actors that effects such as power are produced. As Feldman and Orlikowski (2011, 1242) remind the sociomaterial analyst, 'relations of mutual constitution do not imply equal relations. Rather they are relations of power, laden with asymmetrical capacities for action, differential access to resources, and conflicting interests and norms'. In ANT's pursuit of tracing the relations that are gathered to perform an 'object', networks of power can be revealed, which may be producing and reproducing issues of inequality.

Although both boundary objects and ANT approaches use translation as a key analytical device, they propose slightly different interpretations. In revisiting earlier ANT writings, Star and Griesemer (1989, 390) critiqued ANT's approach to translation, arguing that it championed a single point of translation. They compared this 'funnelling *interessement'* to the managerialist action of the innovator, or engineer, who attempts to enrol other actors through establishing an 'obligatory passage point' (Callon 1986). An obligatory passage point is created through the actions of a specific actor, who identifies other actors it wishes to align interests with, and then positions itself as an indispensable channel through which they must pass, or connect with.

In response to this managerialist critique, Star and Griesemer (1989) proposed an ecological model, which accommodates multiple translations and discourages privileging one viewpoint over others. However, whilst prominent in their original

work on boundary objects, the visibility of 'interessement' has somewhat faded in later management literature (Chow and Leiringer 2014). Furthermore, boundary objects set up boundaries: a dichotomy that ANT fundamentally rejects through its focus on the on-going performance of translation.

Despite these concerns about the anecdotal use of boundary objects and the differences between the two theoretical approaches, there exists a useful corpus of ANT-inspired research that uses boundary objects as an analytical concept to foreground the meditative role of objects. For example, in their study of construction project management, Sage, Dainty, and Brookes (2010) found that considering the project file as a boundary object could help show how project management knowledge was mediated between different actor-networks. Chow and Leiringer's (2014) study on power in public engagement processes foregrounds the role of 'interressement' to show how boundary objects are created and transformed over time through translation. Thompson, Macpherson, and Herbane (2017) worked with the two approaches to explore boundary object ontology and transience in emergency management collaboration. In these studies, the authors have explicitly recognised their nuanced attempts at reconciling ANT with boundary objects. The next sections detail my empirical account, and subsequent discussion, of working with these two theoretical approaches.

Presenting the case: Following the signature as a 'messy object'

Over six months, I conducted an ethnographic study of professional engineers' everyday work in a renewable energy organisation, TurboUK[1]. A leading competitor in

[1] All company, participant and project names have been replaced with pseudonyms to respect anonymity.

the wind energy industry, TurboUK manufactured, sold and constructed wind turbines. I was granted access to their UK office to observe and interview professional engineers and follow the objects of their practice. This particular case was of interest because, due to its emerging and volatile nature, engineers' knowledge practices are often uncodified, improvised, and highly complex. Thus, they resist being categorised, or represented, as rational, stable and bounded engineering knowledge (Trevelyan 2014). An ANT approach to understanding how knowledge was being performed in this kind of industry asked different questions as it situated engineering knowledge as an *effect* of social and material relations, which emerged *in practice* (e.g., Suchman 2000; Jørgensen and Brodersen 2016; Williams, Figueiredo, and Trevelyan 2014). Therefore, this study was concerned with how a relational, materially-mediated approach to studying knowledge practices could inform education practices how to prepare professionals for work in these complex, emerging industries.

Thirteen engineers volunteered as participants (2 women and 11 men: 2 from Sales; 5 from Technical Support; 4 from Project Management; and 2 from Service departments). The data gathered comprised observational field notes, relational maps drawn by the participants, semi-structured interview transcripts, and photographs taken by both myself and the participants. Close attention was paid to tracing the relations between the engineers and the objects of their practices during their everyday work activities. I was looking for gatherings of human and non-human actors that were creating palpable energies in the workplace; where tension and negotiation was rife, and their presence appeared impossible to ignore.

To do so, I followed the actors, looking for moments when the materiality of their practices became visible, either through breakdowns, innovative moments, or when the familiar was made unfamiliar (Latour 2005). The complex work generated

during the signing of a contract provided me with numerous opportunities to attune to these moments of material visibility when 'completely silent intermediaries become full-blown mediators' (Latour 2005, 81). I kept 'bumping' (Adams and Thompson 2016) into the signature: it was constantly referred to in nearly every meeting I attended, and consistently mentioned in the participants' interviews. Therefore, the act of signing the contract, and the work that this generated, appeared as a crucial, yet highly distributed and messy, activity that advanced engineers' everyday work. In fact, it was so messy that I began to view it as a 'messy object'.

Law and Singleton (2005) proposed the idea of 'messy objects' after struggling to research alcoholic liver disease as a single, explainable object. They believed that this was not due to the fact that they 'simply weren't doing good research' (3), but that the disease, as an object to be studied, was enacted in such complex ways that it slipped through most theoretical and methodical interrogation approaches. They point to two strategies for knowing mess. The first concerns the multiple perspectives of an object that are held by different people. This strategy, they argue, is one taken up by the concept of boundary objects. The second is an ontological strategy, which I return to later in this paper.

Several studies have used these two strategies to enhance their understanding of an inherently complex object, such as blood (Wittock, De Krom, and Hustinx 2017) and learning (Fenwick 2010). Fenwick and Edwards (2011) showed that, by approaching educational policy as a messy, incoherent assemblage, rather than a singular entity, policy analysts may be better able to locate possible points for fruitful intervention.

To present the messy work of the signature, I drew on Latour's (2005) endorsement of description and Adam and Thompson's (2016) recommendation of posthuman anecdotes as analytical heuristics. Posthuman anecdotes aim to foreground

non-humans in a descriptive account through narrating, 'in lived-through detail, an incident or life happening that strikes, interests or otherwise concerns us' (Adam and Thompson 2016, 25). In the following section, I offer two posthuman anecdotes, which are crafted from multiple data sources. These were selected to show how Law and Singleton's (2005) suggested epistemological strategy – using boundary objects – was a useful analytical tool to make visible knowledge practices that emerged in the work of a messy object: the signature.

Findings

Signing as a sociomaterial accomplishment

During the study, it became apparent that the primary focus of TurboUK's employees work was to secure sales contracts to sell their wind turbines to clients who were developing wind farms. Often taken for granted, I noticed that obtaining a signature on a contract was the driving force of the engineers' daily work activities. Furthering Gherardi and Landri's (2014) research of signatures as a material apparatus of professionalism, I explored how the act of signing could be viewed as a situated, distributed and inherently material practice. In particular, I was interested in how following the messy, complex work of the signature (and the act of signing), as a boundary object, could elicit particular knowledge practices.

The signing of a contract was a priority for not only the engineers in a sales role at TurboUK, but for engineers employed as electrical, mechanical and civil engineers in technical support, project management and product servicing capacities. Here, a signature was understood as an individual's written name that was personally added to the document in question (a contract), and represented a trusted authoritative validation to uphold the statement of promise contained in the document (Fraenkel 2008). In this

study, a contract was understood as a convention: a legal agreement entered voluntarily by two parties or more.

At TurboUK, a 'project team' was created to manage the lengthy process of arranging the contract, and was comprised of a project manager (a 'PM', from Project Management), a project engineer and an electrical engineer (from Technical Support and Service) and a sales engineer (from Sales). They worked together, with the client, to decide what material constituents would be inscribed in the contract, such as wind turbine component costs, transportation schedules, environmental assessments, and payment plans. If the potential client accepted TurboUK's offer, the contract they had negotiated together would be printed onto paper, ready to be signed by the client and TurboUK representatives. Once autographed, the signed contract represented a joint agreement and shared responsibility for the stipulated terms.

Following an ANT sensibility, I came to understand the work of arranging the signature as a sociomaterial performance, or accomplishment. That is, the work to obtain a signature was a collective achievement of multiple entities, requiring the relational ordering, or alignment, of (often unruly) human and non-human actors. The penned signature acted as a moment of stability, which had pulled into agreement the jostling, competing and over-lapping actor-networks that were mobilised to align all the relevant material constituents.

The following two anecdotes focus on the work of the signature during a particular time and space in the signing process, the arrangement of the pre-signed contract. Neither the signature nor the contract had materialised as a physical manifestation at this point, but was a messy gathering of evaluation forms, timelines, risk assessments, emails, and informal conversations. The first anecdote shows how a material constituent of the pre-signed contract, a timeline, acted as a boundary object

between different engineers in a project team that had been assembled and tasked to arrange a contract for a particularly high-value project.

Anecdote 1: Calibrating different priorities between engineers

Through conducting interviews, and observing a number of project team meetings, I noticed how the mobilisation and flexible interpretation of a timeline invited processes of negotiation between engineers in the Sales departments and engineers in Technical Support and Project Management departments. Each member of the project team contributed their technical expertise to strengthen the networks holding together the pre-signed contract, and to embed expertise, strategies, and requirements into the contract specifications. However, precarious government subsidy initiatives, rival firms competing with more appropriate wind turbine technologies, client demands, and a complex wind farm site in question were acting as over-lapping actor-networks in the signing process, threatening to destabilise the work of the signature.

Consequently, Paul, a sales engineer, was pushing to get the contract signed as quickly as possible, and encouraged a short timeline to complete the Project Contract Evaluation (PCE). The PCE acted as a critical risk assessment tool, whose relevant sections were completed by the corresponding engineer in the project team as part of arranging the contract. This process ensured that the engineers from each department had considered their due diligence, and had addressed the standards of care for each stage of the project.

I heard the sales engineers referring to the PCE timeline as if it could be cemented as a physical object: ‘we are holding the timeline’ and ‘we need to solidify dates’. Meeting requests were sent out, requesting a fortnightly recurring meeting to monitor the progress of obtaining the signature against the timeline. Spreadsheets were circulated, which had translated ‘time’ into digital representations of dates through

Gantt chart software (a project management tool). This materialisation appeared to translate the PCE timeline into what Latour (1987) would term an immutable object – an actor-network that was temporary stable and could evoke different practices from a distance. This gathering of relations into an immutable object enacted a 'vague notion of power' (Latour 1986). The effect created pressure on the other project team members to complete their assessments as quickly as possible. This would satisfy the sales engineers' work objective, a signed contract that represented a project 'won'.

Yet engineers in the other departments were reluctant to commit to a specific PCE completion date until they had ensured that a review of all the technical aspects and potential risks of the project had been thoroughly conducted. From past experiences of this pressured process, the PM and Technical Support engineers had learnt to resist this timeline, and often requested more time; they refused to relate to the timeline as an immutable object. They regarded the PCE as an opportunity to address their professional responsibility, for instance, to health and safety issues, and those attentions took time. External actors would rely on the written contract to shape their work practices. For example, a haulage contractor responsible for delivering wind turbine towers to a wind farm site would refer to the contract for details concerning delivery dates. The PMs would have to anticipate this trajectory when arranging the contracts, ensuring that they had accounted for the relevant health and safety procedures, such as arranging road closures with the council to ensure safe delivery of the turbine towers.

Thus, in ANT terms, I was observing the PM engineers struggling to keep the PCE open as matters of concern (Latour 2004) for as long as possible. That is, they strove to keep questioning, or keep visible, the things that were being gathered, or folded, into the PCE. They were hesitant to close down any controversies that were yet to be resolved, for example, in planning for the transport of the turbine towers. The

sales engineers, conversely, may have been less willing to concede this time. Instead, they argued that they could account for any uncompleted actions by adding them into a risk register. Latour (2004) might say that they wanted to smooth over any unresolved issues by framing the pre-signed contract as 'matters of fact'. When objects are treated as matters of fact, they are approached as stable artefacts. They act as intermediaries that are no longer a source of controversy by translating them into a 'black-box'. Latour (1987) uses this term 'black-box' to describe how the essential, complex and intricate historical networks that are enrolled to make an object work, can become 'boxed up'; hidden from view. The focus thus shifts to what is produced by this black box, with no critical questioning on how it is produced.

In this space of tension, the material relations mobilised by the timeline acting as a boundary object helped keep open this space between the engineers in order to balance the commercial objectives of the organisation, pushed for by the sales engineers, with those practices concerned with ensuring health and safety, quality and risk, which were prioritised by the PMs and technical engineers.

Anecdote 2: Creating a shared space for performing an exchange

The second anecdote draws on the boundary object concept to explore how processes of negotiation with external clients shaped engineers' knowledge practices. Here, negotiation was understood as a transactional process in which both parties reach an agreement about the details of the pre-signed contract through practices of compromise. All those involved understood the symbolic function of a contract, the need for collaboration to achieve its potential, and the implications that a penned signature initiated. In this sense, the pre-signed contract was 'robust enough' (Star and Griesemer 1989, 393) to function as a commonly identifiable artefact, yet flexible enough to address multiple, conflicting perspectives. An inherent part of this flexibility was due to

the pre-signed contract's fragmented nature and the space of exchange it created when working as a boundary object to 'tack back and forth' (Star 2010, 605) as negotiation practices unfolded.

Enacting persuasive performances of negotiation practices seemed a crucial knowledge practice that was not just limited to engineers in a sales role. Acting as a boundary object, the pre-signed contract pulled the engineers in to meetings and discussions that demanded ways of working that were perhaps not accounted for in their pre-service engineering education. For example, the electrical engineers were valued for their technical expertise but, enrolled as part of a collective project team, which represented TurboUK's interests to the client, they were also expected to know how to interact with clients in a meeting. Here, saying the right or wrong thing could have costly consequences, as Paul explained:

> The engineers, you rely on them, on their technical knowledge, but also on their commercial knowledge, not to say the wrong things in the meeting where it might bring more scope and more cost into us. I think you do have to have a level of commercial awareness and an understanding of negotiation, and an understanding of the product. Yes, that comes as a given with the engineering role that you're in not to say the wrong thing, or to say the right thing, or to word it in the correct way that fits what we want and the customer hears what he wants.

It seemed quite a demanding task for electrical or mechanical engineers to know '*as a given'* how to '*word it in the correct way'*. Paul explained how challenging it was to sense when the negotiations were unfolding in their favour:

> It's quite difficult [laughs] we need to explain it in a way that the customer goes 'oh that's fine', and how it actually might happen in practice might be slightly different but it gets the end result. It's not being cloak and dagger kind of stuff but it's certain things when they're talking to us about something and if we know that they have it wrong we'll just stay quiet, 'mm ok we'll accept that', but we know for ourselves that it works in our favour, and we just leave it. It's little things like

> that that. Often you'll get a kick under the table if you're told to keep schtum. It's all part again of the negotiation and not being rash and not making decisions too quickly.

The knowledge practices of negotiation could be understood as a collective and embodied persuasive performance. There were subtle strategies to be learnt by the engineers as they became part of this performance. They had to sense when not to make impulsive decisions, and to value the effect of silences.

Another knowledge practice that emerged was judging the appropriateness of trade-offs, and the professional boundaries these started to complicate, as Paul described:

> The second level behind [the negotiation] is understanding what we could trade in. If we could trade say, ok we'll do the delivery of the foundation rings to site. Now it's a small thing, it's a small cost, it's more work for the project management because they have to coordinate it if we do that work, but we could do something like that in return for them taking on all responsibility for the transport of other components. We'd say you do that section, we'll do this section and then it's all agreed.

Paul was making explicit the tacit assumption about negotiation practices that a performance, in an acting sense, would occur in a meeting. Give and take would be played out between the different actors to satisfy the various objectives. In this practice, the pre-signed contract could again be considered a boundary object, which facilitated a shared space for this exchange. As Koskinen and Makinen (2009, 34) found in their study, 'the intersectional nature of the negotiators' shared work is now a strongly structured boundary object (i.e., project contract) which simultaneously includes multiple views, and meets the demands of each group'. Kellogg, Orlikowski, and Yates (2006, 39) refer to a space such as this as a 'trading zone', where 'diverse groups can interact across boundaries by agreeing on the general procedures of exchange even

while they may have different local interpretations of the objects being exchanged'. It was through these negotiations in the 'trading zone' that Koskinen and Makinen's (2009, 31) participants needed 'to learn to communicate with and from others who have different perspectives and perhaps a different vocabulary for describing their ideas. They need to establish a common ground and a shared understanding'.

However, as the data showed, engendering a fully transparent, shared understanding in this cooperative space was not necessarily conducive to the negotiation outcomes. Knowing how far to push the trade-offs and when (not) to correct clients' misunderstandings emerged as a subtle and nuanced knowledge practice. The engineers also had to judge at what point these negotiation techniques could start to destabilise their professional responsibilities, where being 'cloak and dagger' could impair their client relationship, or even incur unwelcome legal consequences.

In summary, these two anecdotes have shown that, from an ANT perspective, the engineers were treating the pre-signed contract as a flexible 'thing', which enrolled a diverse range of actor-networks. There were moments of contradiction, divergence and disjunction as these heterogeneous networks struggled to align. Positioning the material constituents of the signature (timeline, pre-signed contract) as boundary objects helped make visible the power relations and knowledge practices, which emerged through the negotiation of different perspectives, objectives and understandings of a messy object: the signature.

Discussion

This section addresses the research questions posed at the beginning of this paper. Firstly, did this study respect the original purpose of the boundary object concept?

I begin by attending to Star's (2010) concerns about the scope and scale of the role of the object in question. In line with her recommendations, I worked within a

specific scale (a single organisation), and scope (accomplishing a signature). In both anecdotes, the actors had diverse interests from the outset. Therefore, there was an absence of consensus that necessitated negotiation. As Akkerman and Bakker (2011) point out, it is often tempting to think of boundary objects as positive mediators of cooperation, and is a stance that is often taken up in studies of boundary objects. Star (2010) stresses that this is not necessarily the case: cooperation can occur without consensus, and when consensus is achieved, it is fragile and precarious. As my findings demonstrated, a boundary object, such as the timeline, can often generate disruptive tendencies and generate asymmetrical power relations. In the first anecdote, the engineers were still cooperating, moving forward the work of accomplishing the signature, but the timeline remained a continuous source of disagreement. It was within these spaces of disagreement that particular knowledge practices emerged, such as balancing the demands of professional responsibility with commercial aims.

Translation, a key concept underpinning both boundary objects and ANT, allowed me to follow the work of the signature in detail. In effect, the signature itself was a translation process; it was changing the nature of the work. The discursive practices – recall the sales engineers' language of 'holding the timeline' and 'solidifying dates' - and circulating intermediaries (meeting requests, Gantt charts) helped reinterpret and re-present the interests of others to actively mediate desires, expectations and objectives. Furthermore, in line with Star and Ruhleder's (1996) research, one could argue that the signature was translating the object into infrastructure. With the penning of the signature, the material constituents would become a signed contract that represented a 'standardized form' (Star and Griesemer 1989, 411); a legal convention that was recognised by many different people. The materialisation of the signature

suddenly erased the extensive and tumultuous efforts of coordination and coercion that were on-going in its accomplishment.

However, where Star and Griesemer (1989, 390) reframed the 'Callon-Latour-Law model of translations and *interressement*' into an ecological model, one that appreciated multiple obligatory passage points and thus many viewpoints, my findings spoke more to an ANT approach. The study focused on the *engineers'*, rather than the clients', thus exhibiting a bias towards the interests of the engineers, rather than the whole enterprise, which is perhaps symptomatic of the common critiques that ANT privileges the 'system builder' or 'innovator', reproducing powerful actors.

But what about the compatibility between the theoretical traditions of boundary object and ANT? Fenwick and Edwards (2010) caution the ANT reader about the futility in defining ANT. They refer to ANT as a virtual 'cloud', which is 'continually moving, shrinking and stretching, dissolving in any attempt to grasp it firmly' (Fenwick and Edwards 2010, ix). This ethereal quality, I argue, creates a malleable space for the layering of other concepts, such as boundary objects, in an ANT analysis, particularly when the objects of practice are complex and messy.

Furthermore, there are similarities between the two traditions. Law (2009) stresses that ANT could be better understood as a 'material semiotic' approach in which semiotics, understood as the study of signs and symbols, position language as an actor. One could thus claim that material semiotics may be closely related to symbolic interactionism, with its focus on symbolic meaning of objects and social interaction. Also, both traditions recognise the recursive nature of theory and practice, in that 'theory is embedded and extended in empirical practice, and practice itself is necessarily theoretical' (Law 2009, 141). These arguments support Nicolini, Mengis, and Swan's (2012, 614) justification for combining four theoretical approaches to analyse the roles

of objects: 'Although these four approaches have their own distinctive followers, debates and studies, our contention is that they also share a number of common basic assumptions and, hence, can and should be used together'.

Shifting from an epistemological to an ontological strategy

The two anecdotes described in this paper show the early work of the signature in the lengthy contract process. Up until this point in the analysis, I was working with the boundary object as an epistemological strategy (Law and Singleton 2005) to help make sense of the data. Yet I was also aware that the work of the signature was generating effects that the boundary object concept struggled to account for. In particular, this occurred once the signature had been added to the contract. With the physical materialisation of the signature, my analysis took a different approach that signalled a shift from 'epistemology and representation to practical ontology and performativity' (Jensen 2010, 7). This realisation helps answers the final research question: In this ANT analysis, does the boundary object concept sufficiently account for the complexity and messiness of collaborative work unfolding in an emerging industry?

I return to discuss Law and Singleton's second strategy for analysing mess: an ontological strategy. Whilst it is possible to argue that both symbolic interactionism and material semiotics (ANT) 'describe[s] the making of knowledge, *the epistemological'*, the latter offers a further layer of analyses: it 'explores the enactment of realities, *the ontological'* (Law 2009, 154, original emphasis). Mol's (2002) work on multiple realties in her account of lower limb atherosclerosis has been foundational is questioning a fundamental assumption about how translation produces, 'a single co-ordinated network and a single coherent reality' (Law 2009, 152). Mol (2002) contends that atherosclerosis, as a condition, emerges in different forms, in different places, to produce 'the body multiple'. For example, in the doctor's surgery it is performed as

painful walking, while in hospital it is performed through X-rays, and in radiography as blocked blood vessels. The different material and local practices evoke their own material reality: 'in theory the body may be single, but in practice it is *multiple* because there are many body practices and therefore many bodies' (Law 2009, p. 152, original emphasis). This multiplicity is what I observed once the signature had been added to the printed contract. Although this paper does not present this data, I expand briefly below.

At TurboUK, once the signed paper contract was archived, I observed that the entrenched networks that inscribed the contract with its legal capacity continued to delegate their power from a distance: the work of the signature had not stopped. Here, the signed contract was not only being perceived differently; it was being enacted differently as 'the contract multiple', for example, as a reference tool, a learning manual, and a performance monitor. At this point, I found it more helpful to consider the signature's role as a mediating object through an ontological strategy (Law and Singleton 2005), following Mol's (2002) proposition of multiplicity.

The richness of the data I gathered to support this multiplicity, and the subsequent discussion on ontology and performativity, begs its own paper. The point I want to make here is that it was impossible to follow all the actors implicated in the act of signing due to the object's inherent messiness and complexity. However, it was useful and enriching to approach the analysis from more than just a single theoretical strategy or conceptual approach. This supports Lee's (2007, 314) assertion that, 'the role of material artifacts in practice is incredibly important to collaborative work and is far too complex to be defined by a single concept, however compelling.' Furthermore, as Nicolini, Mengis, and Swan (2012) argue, 'examining the role of objects through different theoretical lenses allows us to see that the role and function of particular objects can change during the course of collaboration' (612), or, as in this study, at

different moments in time and space during the accomplishment of the signature. Thus, I argue that it may be more insightful to study the roles of messy object in complex practices using plural theoretical approaches to more accurately map emerging knowledge practices.

Conclusion

This paper has sought to unpick the tensions around the theoretical concerns outlined by Star (2010) and Trompette and Vinck (2009; 2010), among others, in order to make visible an argument for how boundary objects can be appropriated to strengthen the analytical pursuit of an ANT study. I have shown that the boundary object concept was helpful to highlight the importance of the material, 'invisible work' – that which was unfolding in the spaces between the formalised processes and the 'unreported "back stage" work' (Star 2010, 607) – that was necessary to accomplish a signature. However, as the signature continued to work in multiple ways even after it was archived on a printed contract, I recommend a pluralist theoretical approach to analysing the mediating effects of 'messy objects', which affords the consideration of both epistemological *and* ontological analytical strategies (Law and Singleton 2005).

Furthermore, the issues debated in this paper could raise questions around the need for definitive designations of what a theoretical concept can and cannot do. As Trompette and Vinck (2010) remind us in the name of critique, 'The idea, of course, is not to apply a rigid academic definition to the concept in order to sort out the "right" uses from the "wrong".' I conclude this paper with Mol's (2013, 390) supportive words, advising scholars to avoid the definiteness of definitions, and embrace the mutability of a concept's trajectory: 'Abstain from all attempts to make it definite … keep them fluid, ambivalent, dancing, gerrymandering.'

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References

Adams, C., and T. L. Thompson. 2016. *Researching a Posthuman World: Interviews with Digital Objects.* London: Palgrave MacMilllan.

Akkerman, S. F., and A. Bakker. 2011. "Boundary Crossing and Boundary Objects." *Review of Educational Research* 81 (2): 132-169. doi: 10.3102/0034654311404435.

Bechky, B. A. 2003. "Object lessons: Workplace Artifacts as Representations of Occupational Jurisdiction." *American Journal of Sociology* 109 (3): 720-752. doi: 10.1086/379527

Bresnen, M. 2010. "Keeping it Real? Constituting Partnering Through Boundary Objects." *Construction Management and Economics* 28: 615-628. doi:10.1080/01446191003587711

Boujut, J-F., and E. Blanco. (2003. "Intermediary objects as a means to foster co-operation in engineering design." *Computer Supported Cooperative Work* 12 (2): 205–219.

Bowker, G. and S. Star. 2000. *Sorting Things Out: Classification and its Consequences.* Cambridge, MA: MIT Press.

Briers, M., and W-F. Chua. 2001. "The Role of Actor-Networks and Boundary Objects in Management Accounting Change: A Field Study of an Implementation of Activity-Based Costing." *Accounting, Organizations and Society* 26, 237-269.

Callon, M. 1986. "The Sociology of an Actor-network: The Case of the Electric Vehicle". In *Mapping the Dynamics of Science and Technology: Sociology of Science in the Real World,* edited by M. Callon, J. Law and A. Rip, 19-34. London: Macmillan.

Carlile, P. 2002. "A Pragmatic View of Knowledge and Boundaries: Boundary Objects on New Product Development." *Organization Science* 13 (4): 422-455. doi: 10.1287/orsc.13.4.442.2953

Chow, V. W. and R. Leiringer. 2014. "The Translation of Power: A Study of Boundary Objects in Public Engagement Processes." Paper presented at 30th Annual ARCOM Conference, Portsmouth, UK, 1st-3rd September, 2014.

Engeström, Y. 1987. *Learning by Expanding: An Activity-theoretical Approach to Developmental Research*. Helsinki: Orienta-Konsultit.

Feldman, M. S., and W. J. Orlikoswki. 2011. "Theorizing Practice and Practice Theory." *Organization Science* 22 (5): 1240–1253

Fenwick, T. 2010. “Workplace ‘Learning’ and Adult Education: Messy Objects, Blurry Maps and Making Difference.” *European Journal for Research on the Education and Learning of Adults* 1 (1-2): 79-95.

Fenwick, T., and R. Edwards. 2010. *Actor-network Theory and Education.* London: Routledge.

Fenwick, T., and R. Edwards. 2011. “Considering Materiality in Educational Policy: Messy Objects and Multiple Reals.” *Educational Theory* 61 (6): 709-726.

Fraenkel, B. 2008. “La signature: du signe à l’acte [The signature: from sign to action].” *Sociétiés & Représentations* 25 (1): 13-23. doi: 10.3917/sr.025.0013

Gherardi, S., and P. Landri. 2014. “‘I Sign, Therefore I am’ (Un)stable Traces of Professional Practices.” *Professions and Professionalism*, 4 (2) doi: 10.7577/pp.618

Henderson, K. 1999. *On paper: Visual Representations, Visual Culture, and Computer Graphics in Design Engineering*. Cambridge, MA: The MIT Press.

Jensen, C. B. 2010. *Ontologies for Developing Things: Making Health Care Futures Through Technology*. Rotterdam: Sense Publishers.

Jørgensen, U., and S. Brodersen. 2016. *Engineering Professionalism: Engineering Practices in Work and Education*. Rotterdam: Sense Publishers.

Kellogg, K. C., W. J. Orlikowski, and J. Yates. 2006. “Life in the Trading Zone: Structuring Coordination across Boundaries in Postbureaucratic Organizations.” *Organization Science* 17 (1): 22-44. doi: 10.1287/orsc.1050.0157

Knorr Cetina, K. 1997. “Sociality with Objects: Social Relations in Postsocial Knowledge Societies.” *Theory, Culture and Society* 14 (4): 1-30. doi: 10.1177/026327697014004001

Koskinen, K. U., and S. Makinen 2009. “Role of Boundary Objects in Negotiations of Project Contracts.” *International Journal of Project Management* 27: 31-38. doi: 10.1016/j.ijproman.2007.10.006

Latour, B. 1986. “The powers of association.” In *Power, action and belief. A new sociology of knowledge?* edited by J. Law, 261–277. London: Routledge and Kegan Paul.

Latour, B. 1987. *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge, MA: Harvard University Press.

Latour, B. 2004. “Why has Critique Run Out of Steam? From Matters of Fact to Matters of Concern.” *Critical Inquiry* 30 (2): 225-248. doi: 10.1086/421123

Latour, B. 2005. *Reassembling the Social: An Introduction to Actor-Network Theory*. New York: Oxford University Press.

Law, J. 1992. "Notes on the Theory of the Actor-network: Ordering, Strategy and Heterogeneity." *Systems Practice* 5: 379-393. doi: 10.1007/BF01059830

Law, J. 2002. *Aircraft Stories: Decentring the Object in Technoscience*. Durham, NC: Duke University Press.

Law, J. 2009. "Actor-network Theory and Material Semiotics." In *The New Blackwell Companion to Social Theory,* 3rd ed., edited by B. S. Turner, 141–158. Oxford: Blackwell.

Law, J., and V. Singleton. 2005. Object Lessons. *Organization* 12 (3): 331–355. doi: 10.1177/1350508405051270

Lee, C-F., and M. Amjadi. 2014. The Role of Materiality: Knowing Through Objects in Work Practice. *European Management Journal* 32: 723-734. doi: 10.1016/j.emj.2014.01.004

Lee, P. L. 2007. "Boundary Negotiating Artifacts: Unbinding the Routine of Boundary Objects and Embracing Chaos in Collaborative Work." *Computer Supported Cooperative Work* 16: 307-339.

Modell, S. E. Vinnari, and K. Lukka. 2017. "On the Virtues and Vices of Combining Theories: The Case of Institutional and Actor-Network Theories in Accounting Research." *Accounting, Organizations and Society* 60: 62-78.

Mol, A. 2002. *The Body Multiple: Ontology in Medical Practice.* Durham, NC: Duke University Press.

Mol, A. 2013. "Mind your plate! The ontonorms of Dutch dieting." *Social Studies of Science* 43 (3): 379–396. doi: 10.1177/0306312712456948

Nicolini, D., J. Mengis, and J. Swan. 2012. "Understanding the Role of Objects in Cross-disciplinary Collaboration." *Organization Science* 23 (2): 612-629. doi: 10.1287/orsc.1100.0556

Orlikowski, W. J., and S. V. Scott. 2008. "Sociomateriality: Challenging the Separation of Technology, Work and Organization." *The Academy of Management Annals* 2 (1): 433-474. doi: 10.1080/19416520802211644

Sage, D., A. Dainty, and N. Brookes. 2010. "Who Reads the Project File? Exploring the Power Effects of Knowledge Tools in Construction Project Management." *Construction Management and Economics* 28: 629-639. doi: 10.1080/01446191003725154

Scoles, J. 2018. “Exploring professional engineers’ knowing-in-practice in an emerging industry: An Actor-Network Theory approach.” PhD thesis, University of Stirling.

Star, S. L. 2010. “This is not a Boundary Object: Reflections on the Origin of a Concept.” *Science, Technology and Human Values* 35 (5): 601-617. doi: 10.1177/0162243910377624

Star, S. L., and J. R. Griesemer. 1989. “Institutional Ecology, ‘Translations’ and Boundary Objects: Amateurs and Professionals in Berkley’s Museum of Vertebrate Zoology, 1907-39.” *Social Studies of Science* 19 (3): 387-420. doi: 10.1177/030631289019003001

Star, S. L., & K. Ruhleder. 1996. “Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces.” *Information Systems Research* 7 (1): 111-134. doi: 10.1287/isre.7.1.111

Suchman, L. 2000. “Organizing Alignment: A Case of Bridge-building.” *Organization* 7 (2): 311–327.

Suchman, L. 2005. “Affiliative Objects.” *Organization* 12 (3): 379-99. doi: 10.1177/1350508405051276

Thompson, E., A. Macpherson, and B. Herbane. 2017. “The Structuring Activities of Boundary Objects”. Paper presented at the Organizational Learning, Knowledge and Capabilities Conference, Valladolid, Spain, April 26–28.

Trevelyan, J. 2014. “Towards a Theoretical Framework for Engineering Practice.” In *Engineering Practice in a Global Context: Understanding the Technical and the Social,* edited by B. Williams, J. Figueiredo, and J. Trevelyan, 33–60. London: CRC Press.

Trompette, P., and D. Vinck. 2009. “Revisiting the Notion of Boundary Object.” *Revue d’anthropologie des connaissances* 3 (1): 3-25. doi: 10.3917/rac.006.0003

Trompette, P., and D. Vinck. 2010. “Back to the Notion of Boundary Object (2). The Notion’s Richness in the Ecological Analysis of Innovative Objects.” *Revue d’anthropologie des connaissances* 4 (1): i-m. doi: 10.3917/rac.009.00ii

Wenger, E. 1998. *Communities of Practice, Learning, Meaning and Identity.* Cambridge, UK: Cambridge University Press.

Williams, B., J. Figueiredo, and J. Trevelyan, eds. 2014. Engineering Practice in a Global Context: Understanding the Technical and the Social. London: Taylor & Francis Group.

Windeck, D., J. Weber, and E. Strauss. 2015. “Enrolling Managers to Accept the Business Partner: The Role of Boundary Objects.” *Journal of Management and Governance* 19 (3): 617-653. doi: 10.1007/s10997-013-9277-2

Wittock, N., M. De Krom, and L. Hustinx. 2017. “Making Sense of a Messy Object: How to Use Social Topology as an Analytic Tool for Ethnography of Objects”. In *Ethnographies of Objects in Science and Technology Studies*, ed. J. S. Mewes and E. Sorensen, 65–83. Bochum: Ruhr-Universität Bochum.

Yakura, E. K. 2002. “Charting Time: Timelines as Temporal Boundary Objects.” *Academy of Management Journal* 45 (5): 956-970. doi: 10.2307/3069324

Zeiss, R., and P. Groenewegen. 2009. “Engaging Boundary Objects in OMS and STS? Exploring the Subtleties of Layered Engagement.” *Organization* 16 (1): 81-100.